

The Chemistry of Food

Lecture 2

Chemistry in Context
06525/06529/06509

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1° and 2° Structure

- **Peptide bonds** join amino acids → **the primary structure** is the specific amino acid sequence of a protein

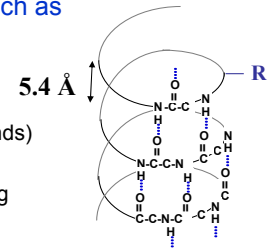
- Ordered structures can be stabilized by H-bonds so forming **secondary structures** such as

- **Helices**

- **β-sheets** (antiparallel peptide strands)

- **disulfide bonds** (R-S-S-R)

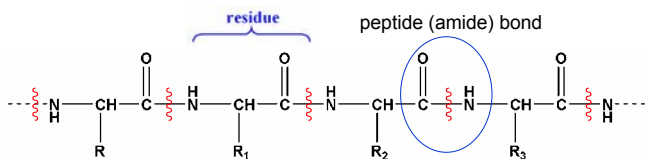
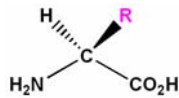
formed by oxidation of neighbouring Cys residues (R=CH₂SH)



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Proteins

- Proteins are polymers of **amino acids**



- Amino acids are **chiral** molecules (except glycine, where R = H)
- Our DNA encodes for *L* amino acids only
- Amino acids can be divided into groups depending on the side chain functionality.
 - Broadly there are hydrophilic and hydrophobic side chains,
 - these can be subdivided into acidic, basic, polar, aromatic and aliphatic

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3° Structure

- **Globular proteins**

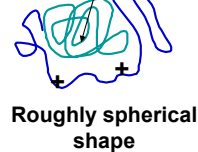
- Hydrophobic residues buried in interior

- Large fraction of hydrophobic units

- Hydrophilic, charged groups on outside

- Most compact structure

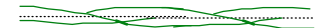
Hydrophobic amino acids avoid contact with water
Charged groups avoid interior



Roughly spherical shape

- **Fibrous proteins**

- More hydrophilic, less compact

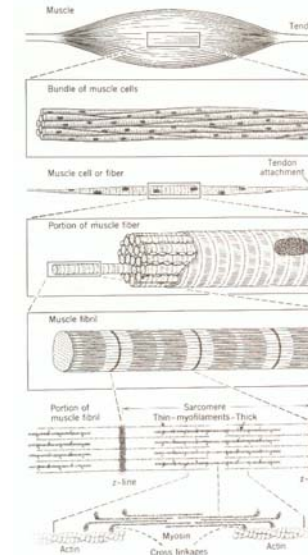


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Essential amino acids

- Amino acids are needed as building blocks
 - for our body's own proteins
 - for purines and pyrimidines (nucleic acids)
 - for porphyrins (e.g. haemoglobin)
 - for other important substances
- The liver can *biosynthesise* some amino acids but others must come from diet – the so-called **essential amino acids**: Ile, Leu, Lys, Met, Phe, Thr, Trp, Val, His
- Proteins are degraded by stomach and intestinal enzymes (proteases) into individual components.

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Muscle
• ends blend in with tendon

Bundle of muscle cells

Muscle cell (or fiber)
• surrounded by sarcolemma
• surrounded by thin connective tissue layer

Muscle fibril

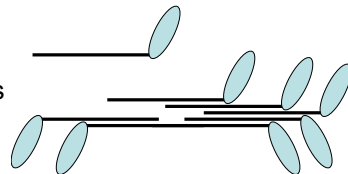
Sarcomere (myofilaments)

Actin and myosin

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Myofibrillar Proteins

- Actin
 - small spheres arranged like string of beads
- Myosin
 - shaped like golf clubs
 - cluster ⇒ thick filaments



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Making Bread: forming dough

- Doughs are **viscoelastic** (they flow and recoil)
- Structure largely from proteins called **glutens**
 - consist of **gliadins** and **glutenins**
 - 30% of amino acid residues are **hydrophobic**
- **Kneading** bread subjects it to **shear** forces
 - promote interactions between **glutenin** molecules
 - H- bonding, hydrophobic interactions, S-S bonds
 - creates elastic protein networks (films) which trap gas
 - viscosity enhanced by **gliadins** and **starch** molecules

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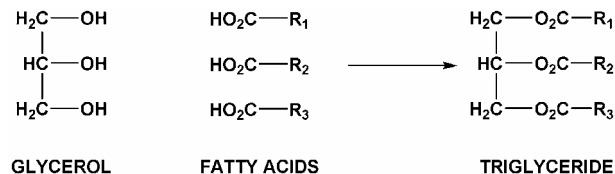
Lipids

- A structurally diverse range of compounds
- Non-polar and hydrophobic
 - Fats (solid at room temperature)
 - Oils (liquid at room temperature)
 - Fatty Acids
 - Triglycerides
- Steroids
- Waxes
- Phospholipids
- Terpenes

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Triglycerides

- Food fats/oils are primarily **triacylglycerols** (esters of fatty acids with glycerol)
- also commonly known as **triglycerides**
 - 3 fatty acid chains on a glycerol backbone



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Attributes of Food Lipids

- Three major functions in foods
 - Energy and health
 - Influence food flavours
 - free fatty acids contribute flavours
 - Texture
 - solid vs liquid
 - mixed with water (emulsions)
- **Attributes determined by types and positions of fatty acids on glycerol backbone**

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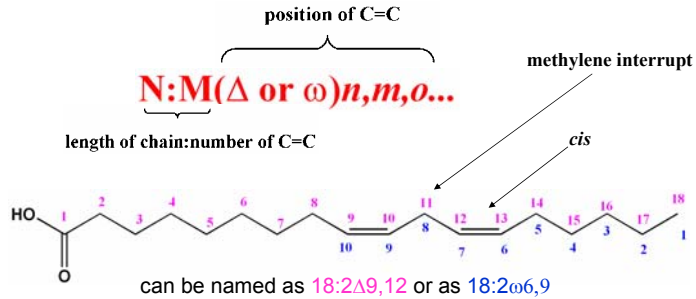
Fatty acids

- Many R groups are **alkyl** groups (no C=C)
 - these are called saturated fatty acids
- Other R groups are **alkenyl** groups (with C=C)
 - 1 to 6 double bonds
 - *cis*-double bonds, methylene interrupted
 - one double bond are called **monounsaturates**
 - two or more double bonds are called **polyunsaturates**

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Naming fatty acids

- Fatty acid chains are named using a specific numbering system.



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Lorenzo's oil

- True story and topic of 1992 film
- Lorenzo's oil is possible treatment for rare disease adrenoleukodystrophy (ALD)
 - involves accumulated saturated, very long chain fatty acids (VLCFA) in blood stream
 - patient cannot break down these VLCFAs
 - especially C26:0
 - synthesized from shorter dietary fatty acids
 - Lorenzo's oil is 50:50 mixture of oleic acid (C18:1) and erucic acid (C22:1)
 - shifts metabolism to form long chain unsaturated fatty acids
- Lorenzo's oil may not affect later disease progression

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Important Food Fatty Acids

Abbreviation	Systematic Name	Common Name	Symbol
4:0	Butanoic	Butyric	B
6:0	Hexanoic	Caproic	H
8:0	Octanoic	Caprylic	Oc
10:0	Decanoic	Capric	D
12:0	Dodecanoic	Lauric	La
14:0	Tetradecanoic	Myristic	M
16:0	Hexadecanoic	Palmitic	P
18:0	Octadecanoic	Stearic	St → 70 °C
18:1	9-Octadecenoic	Oleic	O → 10.5 °C
18:2	9,12-Octadecadienoic	Linoleic	L → -5 °C
18:3	9,12,15-Octadecatrienoic	Linolenic	Ln
20:0	Eicosanoic	Arachadic	A
20:4	5,8,11,14-Eicosatetraenoic	Arachadonic	An
22:1	13-Docosenoic	Erucic	E

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COLOURS

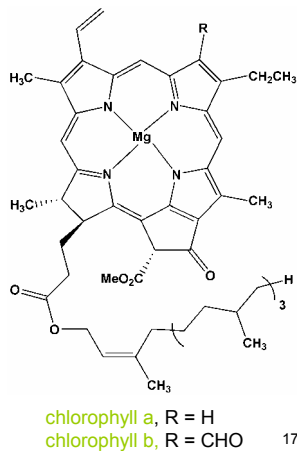
The molecular basis of colour

Colour	Wavelength (nm) Light absorbed	Complementary Colour Colour observed
Violet	400	Yellow
Blue	450	Orange
Green	500	Red
Yellow	550	Violet
Orange	600	Blue
Red	650	Green
	700	

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Colour: green

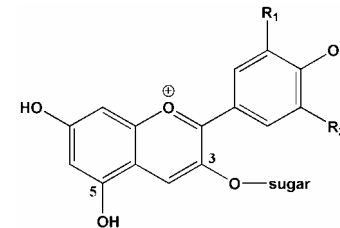
- Leafy green vegetables and apple skins contain **chlorophylls a and b**
- Used in photosynthesis
- Cooking (heating) results in:
 - loss of phytol side chain forming chlorophyllide
 - Loss of magnesium to form **brown** pheophytins (over cooked cabbage)



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Colour: reds, mauves, blues

- The colours in berries and similar fruits are due to the **anthocyanins**
- Contain **anthocyanidin** aglycone often based on the flavylum cation
- Six natural variants (OH, H, OMe) of the aglycone

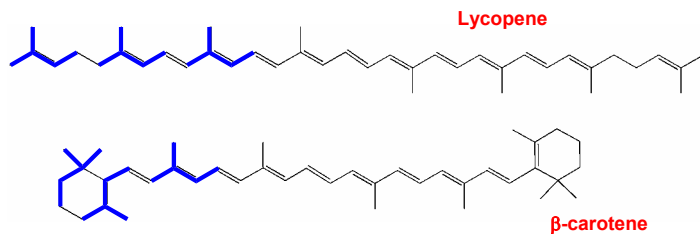


- Can have various sugars attached via glycosidic link at position 3 (sometimes at 5, rarely elsewhere)
- Sugars often esterified at C6 with cinnamic acid derivatives (caffeic = *p*-OH + *m*-OH; coumaric = *p*-OH; ferulic = *p*-OH + *m*-OMe)

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Colour: yellow and orange

- Yellows and oranges are due to the carotenoid group of terpenes, e.g. lycopene and β -carotene

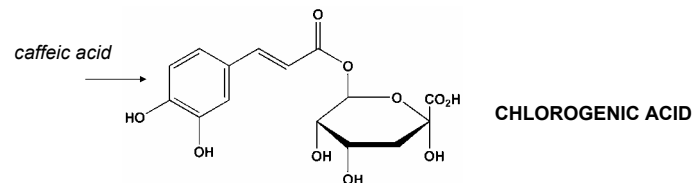


- Terpenes made from repeating **isoprene** units derived from mevalonic acid. Having 8 isoprene units, the carotenoids are **tetra-terpenoids** (monoterpenes have 2 units).

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Colour: browns

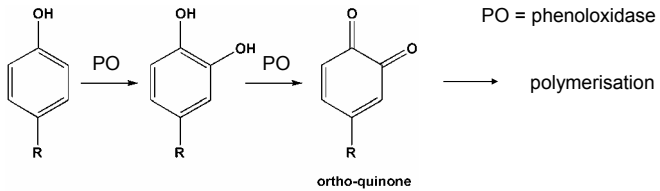
- On cutting apples and potatoes brown rapidly due to the action of **phenoloxidase** on chlorogenic acid



- Oxidation of polyphenols form reactive quinones which then polymerise forming **brown pigments** called melanins
 - Causes **desirable** browning in tea, cider, dried fruit etc.
 - Tannins form as red wine matures – polymerisation of anthocyanins

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Enzymatic browning

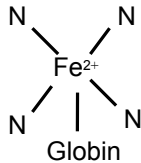


- Prevention of browning
 - Eliminating oxygen (storing in an inert atmosphere or vacuum)
 - Lowering enzyme activity
 - The optimum pH for *phenoloxidase* is 7, and so citric or malic acid can be added to retard browning
 - Briefly heat to deactivate enzyme (blanching)
 - Add reducing agents (ascorbic acid, sulfites)

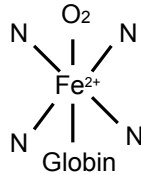
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The colour of your steak

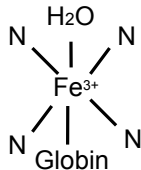
- Myoglobin
 - protein containing iron
 - purplish-red
 - Fe^{2+}



- Oxymyoglobin
 - supermarket red
 - Fe^{2+} O_2



- Metmyoglobin
 - brownish-red
 - Fe^{3+} H_2O



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